cotton or cotton fabrics by ordinary microscopical examination in cases where surface growth is not present. In such cases, and also when it is necessary to determine the extent of infection, differential staining followed by microscopical examination is desirable. For this purpose, Bright[1] recommends the use of cotton blue or picronigrosine for staining, mounting the material in Canada balsam, and examining with the 2/3 inch (16 mm) objective. Color filters may be used to obtain greater contrast.

We have found that the Pianese IIIb stain,[2] which is used by plant pathologists in studying sections of tissue infected by fungi, is also a good differential stain for the above purpose. This stain contains martius yellow, malachite green and acid fuchsin.[3] The material under examination is washed in water or alcohol (preferably alcohol), stained for 15 to 45 minutes, washed in water, decolorized in acid-alcohol and dried, after which it may be mounted for examination in Canada balsam or gum damar. Cotton fibers stain green and the fungus mycelium a deep pink, a color filter not usually being necessary for contrast. A good source of light is important.

With this stain the presence of fungus mycelium in raw cotton and undyed yarns and fabrics is easily and quickly demonstrated. It is desirable in heavy fabrics to tease the fibers apart before mounting. Dyed cloth is sometimes more difficult to examine, but fungus, if present, can usually be demonstrated.

M. W. JENNISON

DEPARTMENT OF BIOLOGY,
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

[1] T. B. Bright, *Jour. Mic. Soc.*, 141, 1925.

[2] R. E. Vaughan, *Ann. Mo. Bot. Gard.*, 1: 241, 1914.

[3] H. J. Conn, "Biological Stains," second edition, 1929.

SPECIAL ARTICLES

CHANGING THE CHIRP-RATE OF THE SNOWY TREE CRICKET OECANTHUS NIVEUS WITH AIR CURRENTS

IT has long been known that the intermittent chirping rate of the snowy tree cricket varies rather consistently with changes in air temperature; Margarette W. Brooks,[1] of Salem, Massachusetts, was the first observer to present in a scientific magazine an account of the rate as affected by different temperatures. Strangely enough, although many scientific discussions have followed up to the present time, every one has consistently failed to make any reference to her pioneer discussion, even though little has been added since her day.

While the rate of chirping unquestionably shows a marked temperature correlation rising and falling with similar changes in temperature trends, the crickets are very erratic organic clocks and show various discrepancies in their rates which have never been explained. Every individual cricket, like every clock or watch, must be regarded as a specific mechanism with specific modes of behavior. These have become geographic correlations in some instances so that in different portions of their range the rates of chirping appear to be physiologically established racial behaviors, as pointed out by Fulton.

Careful observations even in the same locality reveal occasional discrepancies from the expected rate which have never been satisfactorily explained. A. F. Shull[2] in 1907 studied these tree crickets very intensively in Michigan, Ohio and New York. He found that observed air temperatures did not explain the entire situation and found that a higher rate now and then may accompany a somewhat lower temperature. In my own studies I have likewise found that on different evenings with air temperatures at 70° the rate may range from 121.7 to 133.7 chirps per minute.

These variations have puzzled me not a little, and during the summer of 1929 I made a few preliminary tests with air currents. A small electric fan was purchased and a snowy tree cricket showing a ready willingness to chirp when confined in a room was placed on some raspberry shoots in my sleeping room where outside air currents could not introduce errors. Using a stop watch a number of counts were then made of its normal chirping rate for these conditions to establish a system of channels. Following this, a current of air was directed upon the cricket from the fan placed about 6 feet away so that it produced an evident motion in the foliage surrounding it. Almost immediately the cricket responded to the air currents by accelerating at once its chirping rate in a very evident manner.

After counts had been made the fan was turned off and the cricket allowed to chirp for a few minutes until the normal rate of chirping in still air could be resumed. The return from the higher rate seemed to require a somewhat longer time than was required to establish it when the fan was turned on.

[1] "Influence of Temperature on the Chirp of the Cricket," *Popular Science Monthly*, 20: 268, November, 1881, to April, 1882.

[2] *Canadian Entomologist*, 39: 213–225.

CHIRPING RATES OF SNOWY TREE CRICKET AS AFFECTED BY A GENTLE CURRENT OF AIR FROM A SMALL ELECTRIC FAN. TIME 11–11: 30 P. M. AIR TEMPERATURE IN ROOM 74° F.—RELATIVE HUMIDITY UNKNOWN

Period	Conditions	Chirps per minute in individual counts	Mean
first	without fan	172, 172	172
first	with fan	192, 188	187
second	without fan	174, 170, 172	172
second	with fan	186, 188, 180	184.6
third	without fan	172, 172, 172	172
third	with fan	180, 188	184
fourth	without fan	174, 174, 172	173.3
fourth	with fan	184, 184, 184	184
fifth	without fan	176, 172, 170	172.6
fifth	with fan	182, 186, 180, 186	183.5
sixth	without fan	172, 172, 170	171.3
sixth	with fan	182, 188, 188, 188	186.5
seventh	without fan	172, 172, 170, 168	170.5
seventh	with fan	182, 188	185

Mean of all counts without fan: 171.9 chirps per minute.

Mean of all counts with fan: 185 chirps per minute.

It is seen that the mean chirping rate has been increased from about 172 chirps per minute to 185 chirps, a difference of 13 chirps above the normal rate in quiet air. The mean acceleration per degree rise of temperature as determined from all available records for the snowy tree cricket is very close to 4 chirps per minute. An increase of 13 chirps following the turning on of the fan to create a breeze is closely equivalent to a rise in temperature of about 3 degrees.

These results were somewhat startling to me, for I had expected a fall in the rates of chirping rather than a rise; I had surmised that moving air currents directed upon the cricket would increase the evaporative rate, tend to chill the cold-blooded creature and depress its activities as reflected in the rates of chirping.

These results agree well with casual observations made in the field with various intermittent chirping crickets, namely, the snowy tree crickets (*O. niveus*) and the tiny tree crickets *Cyrtoxipha gundlachi columbiana*. Many times I have noted a sudden speeding up of the chirping rates as a breeze swept over the foliage on warm evenings. The transportation of a warmer air mass to replace a cooler could operate, but as the room tests have shown, it may even depend upon moving air at constant temperature.

In a test made later in the season out-of-doors, the fan was arranged to blow a current of air upon a chirping cricket on a shrub. At this time, however, the moving air currents produced no changes in the rates of chirping of the cricket.

It is obvious that the matter is not as simple as might at first appear, and it is possible that temperature and humidity must bear certain relations to air motion to determine whether or not retardation or acceleration of the chirp-rate per minute will occur.

It is interesting to note that A. F. Shull[3] found certain obvious discrepancies in the rates of chirping at different elevations which were not explainable on the basis of observed differences in air temperature. Whereas the difference in temperature between crickets at an elevation of two feet and those at 10 feet was only 1°, which should have increased the rate but 4 chirps at the higher point, the increase was actually 17 chirps. In his discussion of humidity Shull (p. 220) studies chirping crickets at 6 and 12 feet elevations. The first set of data was made with a clear sky and no air currents. Two hours later a second set was made when the temperature at the higher elevation had fallen about 2.2°, attended by light winds and rain. The change in temperature at 12 feet would have accounted for a decrease of but 9 chirps per minute, but the actual decrease had become 20 per minute.

Shull was inclined to believe that increase in humidity decreased the rate of chirping, and consequently would account for the lower rates observed at an elevation of 2 feet as compared with 10 feet. He believed that the greater depression at 12 feet over that at 6 feet was likewise due to an increased humidity.

My own results and those of Fulton appear to indicate no correlation between normal out-of-doors conditions of relative humidity and the rate of chirping. At very low humidities such as are not usually experienced by the crickets out-of-doors the relations may be very different, however. It may be stated that some phase of the matter of wind velocity may account for some of the discrepancies observed by Shull. Before any final statements can be made, the behavior of the crickets must be noted in constant air movements at different levels of temperature and humidity. An acceleration in the rate at one temperature and humidity level may be replaced by a depression at some other level.

Since the crickets, like other insects, are cold-blooded creatures, their temperatures tending to assume the levels of their conditions, it is not hard to conceive of relations between air temperature and humidity where air currents by increasing the evaporative processes would chill or benumb the crickets to

[3] "The Stridulation of the Snowy Tree-Cricket, (*Oecanthus niveus*)," *Can. Ent.*, 39: 213–225, 1907.

a greater or less degree. This may well not hold at all temperature and humidity levels, however.

When air currents blow upon them it is not so easy to see why the crickets under some conditions are stimulated to greater physical exertion as evinced by an increase in the chirping rate. Is it possible that the air currents make them more comfortable by cooling their bodies, under some conditions, just as it sometimes affects our own moods? It is at least indicated that air movements in some manner may at times operate to change the rate of chirping, and this factor may perhaps explain in part some of the discrepancies observed where the rates have changed out of proportion to the changes in air temperature.

While it is obvious that air temperature alone is not the only factor operating to make our cricket thermometers accurate, we are not justified in minimizing the air temperature factor, however. The evaluation of one factor in any environmental complex without due regard to all others can only result in confusion.

H. A. Allard

U. S. Department of Agriculture

FRUIT-BUD FORMATION IN THE STRAWBERRY IN SPRING IN SOUTHEASTERN STATES

After the strawberry season is entirely past in Maryland one may travel either southward or northward and find strawberries just ripening. Even in Florida where the ripening season starts in November, berries may still be harvested as late as July. It is evident that the processes of fruit-bud formation and fruit development in the South take place under different conditions from the same processes in strawberries growing farther north.

In various sections of the Northern states from Maryland to Iowa and northward, the terminal growing points of strawberry plants have been found to begin transforming from vegetative buds to fruit buds in late September and October. In Florida the varieties there evidently initiate fruit buds continuously throughout late fall, winter and spring, as flower cluster production is a continuous process from November until June. From Georgia to North Carolina winter temperatures are cold enough to enforce short dormant periods, but the fruit-bud formation of fall is again resumed as soon in the spring as the temperatures become high enough for growth. From Virginia northward there seems to be no period of spring fruit-bud formation, and consequently no second crop.

The work of Garner and Allard,[1] and work previously referred to in this periodical[2] on effects of the length of the daily light period on plant growth, have furnished a background for an explanation of this late spring fruiting of the strawberry in the South. This work also furnishes one reason why strawberries vary so greatly in yields in different localities.

Fruit-bud development does not begin in the spring-bearing varieties to the north until the daily light period becomes relatively short in the late fall, and it ceases as soon as the temperature is as low as freezing. It would seem that conditions of similar day length and temperature following a period of winter dormancy might influence strawberry-plant activity in the same manner as preceding the dormant period. The following observations give evidence that fruit-bud initiation is resumed in the Southeast from Georgia northward to North Carolina in early spring while the temperatures are still low and the length of the daily light period still short. North of eastern North Carolina, the daily light period is too long for fruit-bud initiation in spring-bearing varieties when favorable temperatures for growth occur.

Missionary and Klondike, the only varieties produced commercially in the Southeast, have little or no rest period and grow freely during the short days of winter when the temperature is high enough. In the spring their fruit buds that formed in the fall and early winter develop into the "ground bloom" and the "ground fruit," terms that refer to the flowers and fruit lying on the ground. The ground bloom of all varieties observed is produced chiefly, if not entirely, on basal-branching clusters,[3] the flowers of which often open in considerable numbers during the late fall and winter months and of course are killed by freezing temperatures where they occur. From Georgia to North Carolina there appears a second crop of bloom and fruit known as the "crown bloom" and "crown fruit." This fruit is produced mainly on high-branching clusters with stout erect stems which support the berries unless they are too large and heavy.

The most vigorous plants produce low, but not basal-branching clusters (at least not usually) that resemble those of the ground bloom but which of course appear later. The extent of the crown bloom varies from year to year, depending on conditions little understood, though both the vigor of the plants in the fall and the weather conditions in winter and spring affect the amount of fruit buds produced in the spring. At Willard, North Carolina, the initial stages of fruit-bud formation have been found as late

[1] W. W. Garner and H. A. Allard, "Further Studies in Photoperiodism: The Response of the Plant to Relative Length of Day and Night," *Jour. Agr. Res.*, 23: 871–920, 1923.

[2] G. M. Darrow and G. F. Waldo, "The Practical Significance of Increasing the Daily Light Period of Winter for Strawberry Breeding," Science, 69: 496–497, 1929.

[3] G. M. Darrow, "Inflorescence Types of Strawberry Varieties," *Amer. Jour. Botany*, 41: 571–585, 1929.